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㉕ Applicant: Daikin Kogyo Co., Ltd., No. 12-39, Umeda 1-chome Kita-ku, Osaka (JP)

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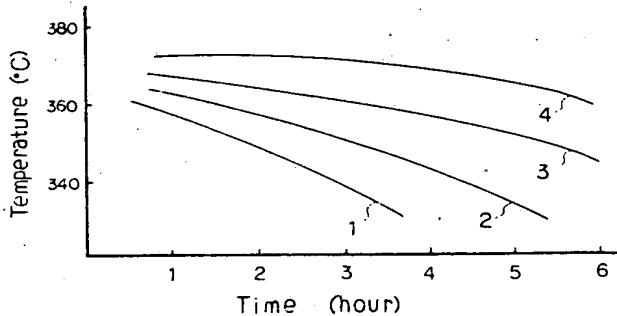
㉗ Inventor: Yoshimura, Tatsushiro, No. 28-3, Ankoji-cho, 1-chome, Takatsuki-shi Osaka-fu (JP)
Inventor: Tominaga, Shigetake, No. 8-26, Nakahozumi 2-chome, Ibaraki-shi Osaka-fu (JP)

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㉙ Representative: Türk, Dietmar, Dr. rer. nat. et al, Redies, Redies, Türk & Gille, Patentanwälte
Brucknerstrasse 20, D-4000 Düsseldorf 13 (DE)

㉚ A melt-processable fluorine-containing resin composition.

㉛ A melt-processable fluorine-containing resin composition having an improved thermal stability which comprises a tetrafluoroethylene copolymer, a chlorotrifluoroethylene homo- or co-polymer, or a vinylidene fluoride homo- or co-polymer and at least one thermal stabilizer selected from the group consisting of an amine antioxidant, an organosulfurous compound, an organo tin antioxidant, a tin powder and a zinc powder. The composition can be advantageously processed without causing any trouble even at an optimum sintering temperature of the fluorine-containing resin. Fig. 1 is a graph showing the sintering of such resin compositions under varied temperature and time conditions.



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1 A MELT-PROCESSABLE FLUORINE-CONTAINING RESIN
COMPOSITION

The present invention relates to a melt-processable fluorine-containing resin composition having an excellent thermal stability, and more particularly to the composition comprising a tetrafluoroethylene (hereinafter referred to as "TFE") copolymer, a chlorotrifluoroethylene (hereinafter referred to as "CTFE") homo- or co-polymer or a vinylidene fluoride (hereinafter referred to as "VdF") homo- or co-polymer, and a thermal stabilizer, which has an improved thermal stability to high-temperature sintering and is processable under conditions of widen ranges with technical and economical advantages and also can provide an article having excellent physical properties.

TFE copolymers and CTFE or VdF homopolymer and copolymers are melt-processable fluorine-containing resins having especially high thermal resistance among

those put on the market, and for instance, as the former there are known TFE-hexafluoropropylene copolymer, perfluorovinyl ether-TFE copolymer, ethylene-TFE copolymer and ethylene-propylene-TFE copolymer and as the latter there
5 is known ethylene-CTFE copolymer. Since these melt-processable fluorine-containing resins have such melt-flowability that the melt viscosity is generally lower than 10^6 poises at an optimum processing temperature for each resin, they provide a film having less pinholes and voids
10 as compared with polytetrafluoroethylene which is a typical and the most usual fluorine-containing resin (the melt viscosity of which is from 10^{10} to 10^{11} poises even at a processing temperature, i.e. about 380°C . and which does not show melt-flowability), and can be used for coatings and
15 linings not only in the form of dispersion, but also in the form of powder coating. Also, the obtained films have excellent chemical resistance and corrosion resistance.

However, the thermal stability of these melt-processable resins at high temperatures in the vicinity of their sintering temperatures is inferior to that of polytetrafluoroethylene, and this is often disadvantageous to processing. For instance, the TFE-hexafluoropropylene powder causes a problem that a part of a resin decomposes and gasifies to cause foaming in the film upon sintering,
20 when a coating composition is applied in a thickness of more than 100μ per one application. Therefore, when it is desired to obtain a film, e.g. a corrosion resistant lining having a thickness of $1,000 \mu$, in general a coating composition must be applied repeatedly in more than 10
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layers and disadvantage in process is unavoidable. Also, even in a case where a film having a thickness of less than 100 μ is formed by one coating process, the film is liable to include bubbles partly inside the film. That is to say, when the resins are heated at a proper sintering temperature of 340° to 380°C. for a long time more than 30 minutes, a part of the resins cause thermal deterioration, and particularly when the coating thickness is large, foaming is noticeable. This phenomenon is accelerated by the influence of oxygen in air.

For this reason, for instance, in case of TFE-hexafluoropropylene resin, there are proposed (1) a process in which thickness of a coating per one application is made as small as possible (about 50 μ) and the application and sintering procedures are repeated many times until a sintered film having a desired thickness is obtained, and (2) a process in which a resin having a low molecular weight (of which melt viscosity is about 0.5×10^4 to about 7×10^4 poises at 380°C.) or a resin having a high molecular weight of which melt viscosity of about 1×10^5 to about 4×10^5 poises at 380°C. is lowered by heat treatment is employed as a material for a coating composition so that the resin melts and flows at a lower temperature, and the coating is sintered at a temperature of 320° to 340°C. to give a sintered film.

However, the above process (1) has the disadvantage that the formation of a film having a thickness necessary in general for corrosion resistant linings, i.e. about 600 to about 1,000 μ requires much labor and time in

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application and sintering.

Also, the above process (2) accompanies foaming during sintering, though the sintering is conducted at a lower temperature (320° to $340^{\circ}\text{C}.$), when a coating composition is applied in a thickness of more than $100\ \mu$ per one application. Therefore, when it is desired to obtain a film having a thickness of more than $1,000\ \mu$, the application and sintering must be repeated more than 10 times as in the process (1). Thus, the process (2) is also low in productivity and is not economical. Further, a low molecular weight resin is inferior in stress crack resistance and solvent crack resistance and is not desirable as a corrosion resistant material. Moreover, thermal resistance of the resin is lowered and, therefore, the allowable processing temperature and time ranges are narrow so that thermal deterioration of resin may take place, thus causing drooping of a lining or lowering of durability of a lining during the processing. In case of providing a large-sized material, e.g. a material having a length of more than one meter or a material having an irregular thickness, with a lining, temperature distribution of sintering and difference in heat history become, of course, large, and a uniform lining of good quality is hard to obtain by the process (2).

Also, in case of ethylene-propylene-TFE copolymer and ethylene-CTFE copolymer, the foaming phenomenon upon sintering after powder coating is not so frequent as TFE-hexafluoropropylene copolymer. However, when the sintering for a long time is required owing to the size and shape of

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a material to be coated, it accompanies deterioration of the resin, and as a result, the obtained film is colored and also the durability to various environments and chemical reagents is remarkably impaired.

5 There are known various processes for improving the thermal stability of these fluorine-containing resins upon sintering. For instance, Japanese Unexamined Patent Publication Nos. 122155/1976 and 122156/1976 disclose a process for improving the thermal stability of the resins by admixing two kinds of TFE-hexafluoropropylene copolymer with different melt viscosities, thermally treated at a high temperature in the presence of steam. These processes require not only the thermal treatment of TFE-hexafluoropropylene copolymer at a high temperature of 340° to 380°C.
10 15 for 2 to 5 hours, but also drying for several hours to remove moisture because of the thermal treatment in the presence of steam, and accordingly is not economical.

It is also known to use, as a thermal stabilizer for ethylene-TFE copolymer, sulfates with metals of Group IV-A of the Periodic Table such as Sn and Pb as disclosed in Japanese Patent Publication No. 37980/1973; phosphates of alkali metals, barium or metals of Group IV-A of the Periodic Table as disclosed in Japanese Patent Publication No. 37981/1973; a combination of organo phosphites and 20 25 phosphates of alkali metals, barium or metals of Group IV-A of the Periodic Table as disclosed in Japanese Patent Publication No. 38215/1973; and α -alumina as disclosed in Japanese Unexamined Patent Publication No. 87738/1974. However, these thermal stabilizers merely inhibit the

discoloration by thermal degradation of ethylene-TFE copolymer in the sintering at 300°C. in 30 minutes, and are not suitable for coating a substrate to be coated having a large size and a large heat capacity.

5

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1, 2 and 3 are graphs showing critical sintering conditions of the melt-processable fluorine-containing resin compositions of the present invention which 10 contain metal powders as thermal stabilizers.

SUMMARY OF THE INVENTION

The present invention provides a melt-processable fluorine-containing resin composition having an improved 15 thermal stability which comprises a melt-processable fluorine-containing resin selected from the group consisting of a tetrafluoroethylene copolymer, chlorotrifluoroethylene homopolymer, a chlorotrifluoroethylene copolymer, vinylidene fluoride homopolymer and a vinylidene fluoride copolymer, and 20 at least one thermal stabilizer selected from the group consisting of an amine antioxidant, an organosulfurous compound, an organo tin antioxidant, a tin powder and a zinc powder.

According to the present invention, the composition can be applied with a large thickness per one application 25 and can be sintered under temperature and time conditions, of which allowable ranges are wide, to give a film having excellent chemical and thermal resistances.

DETAILED DESCRIPTION

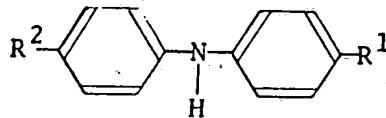
The melt-processable fluorine-containing resins employed in the present invention are TFE copolymers, CTFE homo- and co-polymers, VdF homo- and co-polymers mainly containing TFE, CTFE or VdF, and their homo- and co-polymers modified with other copolymerizable monomers, and moreover are those melt-flowable with heating. These resins include (1) TFE-hexafluoropropylene copolymers containing residues of TFE and hexafluoropropylene in a molar ratio of 95 : 5 to 75 : 25, (2) TFE-perfluorovinyl ether copolymers containing residues of TFE and perfluorovinyl ether in a molar ratio of 98 : 2 to 90 : 10, (3) TFE-ethylene copolymers containing residues of TFE and ethylene in a molar ratio of 70 : 30 to 90 : 10, and (4) TFE-ethylene-propylene copolymers containing residues of TFE, ethylene and propylene in a molar ratio of 40 to 60 : 25 to 50 : 2 to 20, (5) CTFE homopolymer, (6) CTFE-ethylene copolymers containing residues of CTFE and ethylene in a molar ratio of 75 : 25 to 85 : 15, (7) VdF homopolymer, (8) VdF-TFE copolymers containing residues of VdF and TFE in a molar ratio of 70 : 30 to 90 : 10 and (9) VdF-hexafluoroisobutylene copolymers containing residues of VdF and hexafluoroisobutylene in a molar ratio of 40 : 60 to 70 : 30. These homopolymers and copolymers may be modified with other copolymerizable monomers such as propylene, isobutylene, vinyl fluoride, vinylidene fluoride, trifluoroethylene, hexafluoropropylene and hexafluoroisobutene, and the modified copolymers can also be employed in the present invention. There are preferably employed in the present invention the above-

mentioned resins having a particle size of 32 meshes (sieve opening: 495 μ) pass, especially 60 meshes (sieve opening: 246 μ) pass.

In the present invention, it is necessary to
 5 employ, as a thermal stabilizer, at least one member selected from (a) an amine antioxidant, (b) an organo-sulfurous compound, (c) an organo tin antioxidant and (d) a tin and/or zinc metal powder.

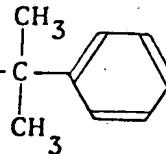
The amine antioxidants usable in the present
 10 invention are antioxidants usually employed for polyolefin resins, and include dinaphthylamine, phenyl- α -naphthylamine, phenyl- β -naphthylamine, diphenyl-p-phenylenediamine, di- β -naphthyl-p-phenylenediamine, phenylcyclohexyl-p-phenylene diamine, aldol- α -naphthyl-diphenylamine, and
 15 their derivatives such as those obtained by introducing a substituent group to phenyl or naphthyl group of the above antioxidants, e.g. a reaction product of diphenylamine and diisobutylene, and a diphenylamine derivative having the following general formula [I]:

20



[I]

wherein R¹ and R² are



or octyl group.

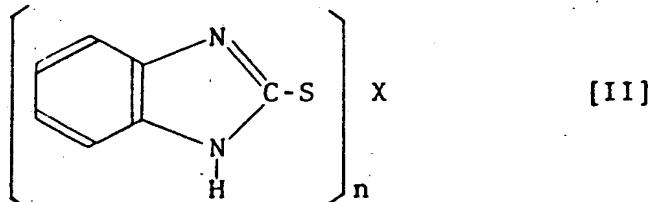
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These amine antioxidants may be employed singly or in admixture thereof.

Examples of the organosulfurous compound employed in the present invention are benzoimidazole type mercaptan

compounds and their salts having the following general formula [II]:

5



wherein X is H, Zn, Sn or Cd atom, and n is an integer of 1 to 4,

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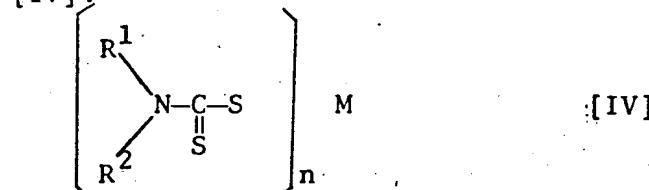
benzothiazole type mercaptan compounds and their salts having the following general formula [III]:

15

wherein X is H, Zn, Sn or Cd atom, and n is an integer of 1 to 4,

dithiocarbamic acids and their salts having the following general formula [IV]:

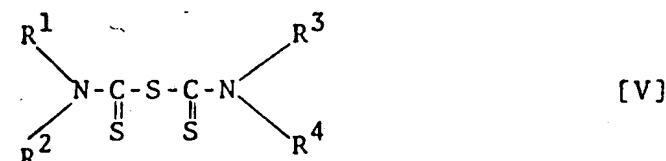
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wherein R¹ and R² are an alkyl or aryl group having 2 to 16 carbon atoms, M is H, Zn, Sn, Cd or Cu atom, and n is an integer of 1 to 4,

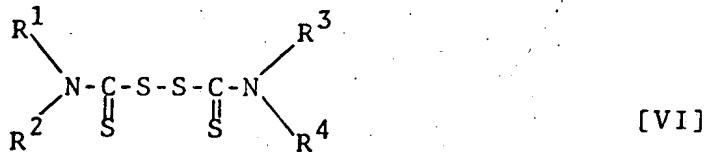
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thiuram compounds, e.g. thiuram monosulfide, having the following general formula [V]:



wherein R¹, R², R³ and R⁴ are an alkyl or aryl group having 2 to 16 carbon atoms, thiuram compounds, e.g. thiuram disulfide, having the following general formula [VI]:

5



wherein R¹, R², R³ and R⁴ are an alkyl or aryl group having 2 to 16 carbon atoms.

These organosulfurous compounds may be employed singly or in admixture thereof.

Organo tin compounds having the following general formula [VII]:

15



wherein R¹ and R² are the same or different and each is an alkyl or aryl group having 2 to 16 carbon atoms, and Y is a residue of an acid, an alcohol or an mercaptan from which hydrogen atom is removed so as to bond to tin atom, are employed as the organo tin antioxidant in the present invention. Typical examples of the organo tin antioxidant are dialkyl, alkylaryl or diaryl tin mercaptides, and dialkyl, alkylaryl or diaryl tin maleates.

The particle size of the above-mentioned organic stabilizers is not particulary restricted, but those having

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a particle size of not more than 70 μ are preferably employed.

Commercially available tin and zinc metal powders are suitably employed in the present invention.

5 Particularly, from a viewpoint of dispersibility into resin it is preferred to employ the metal powder having a particle size of not more than 30 meshes pass, especially not more than 60 meshes pass, and in general the metal powder having an apparent dry sieve size of not more than 10 100 to 200 meshes is employed. The tin powder and zinc powder may be employed singly or in admixture thereof.

The above-mentioned organic compounds employed as the thermal stabilizer in the present invention have been considered to be ineffective as thermal stabilizers for fluorine-containing resins which melt at a high temperature, since they rapidly thermally decompose and gasify in a temperature range of about 300° to about 400°C. which is the sintering temperature of the melt-processable fluorine-containing resins. In fact, phenol type antioxidants widely employed for polyolefins have no effect as the thermal stabilizer on the melt-processable fluorine-containing resins employed in the invention or impair the thermal stability, even if they are employed singly or in combination with other phenol type antioxidants.

25 The organic compounds employed as the thermal stabilizers in the present invention have a surprising effect of thermally stabilizing the melt-processable fluorine-containing resins when they are employed singly or in particular in combination of two or more kinds of the

stabilizer, despite that about 80 % by weight decomposes and gasifies at a temperature of about 380°C., and the fluorine-containing resins can be maintained stable during sintering over several hours.

5 The thermal stabilizer is employed in an amount of 0.05 to 10 parts by weight, preferably 0.1 to 5 parts by weight, more preferably 0.5 to 3 parts by weight, per 100 parts by weight of the melt-processable fluorine-containing resin. When the amount of the stabilizer is smaller than
10 the above range, the effect of improving the stability is poor. Also, when the amount is larger than the above range, the obtained film is colored or the chemical resistance of the film is decreased.

Any known other additives may suitably added to
15 the fluorine-containing resin composition of the present invention, e.g. pigments such as carbon black, titanium dioxide and cobalt oxide, reinforcing agents such as glass or carbon fiber powder and mica, leveling agents, and antistatic agents.

20 The fluorine-containing resin composition of the present invention may be employed in the form of solid for molding processing, or in the form of dispersion or slurry wherein the composition is dispersed in an organic medium or an aqueous medium.

26 Any of dry and wet methods may be applicable to blending the melt-processable fluorine-containing resin and the thermal stabilizer, and is suitably selected according to the desired form of the composition for use. When it is desired to obtain the composition suited for

use in powder coating, it is, of course, preferable to conducting the blending in the form of powder, and in which usual blenders and pulverizers such as sample mill, V shape blender, cone shape blender and ribbon mixer may be employed without particular limitation. In case of the organic stabilizers, it is necessary to conduct the blending at a temperature of less than about 200°C. so that the stabilizers are not influenced by heat, and for the same reason it is also necessary to take care so that the composition is not subjected to the influence of heat at a temperature higher than about 200°C. prior to using it for coating. When the blending is carried out by a wet method, the fluorine-containing resin and the stabilizer are blended in water, in an organic solvent such as toluene, xylene, chloroform, perchloroethylene, trichloroethylene or an alcohol, or in a mixture of water and the organic solvent. In case of using water as a medium, in order to uniformly disperse the thermal stabilizer it is preferred to add a surface active agent such as sodium alkylbenzenesulfonate, sodium alkylsulfate, polyethyleneglycol alkylphenyl ether, polyethyleneglycol alkyl ether or ammonium perchlorofluorocaprylate. The wet blending is conducted by employing any apparatuses for agitation or blending such as ball mill, vibrating ball mill, sand mill and roll mill without particular limitation.

The present invention is more particularly described and explained by means of the following Examples and Comparative Examples, in which all parts are by weight unless otherwise noted.

Examples 1 to 44 and Comparative Example 1

A 50 liter kneader having four agitating blades (commercially available under the tradename "Speed Kneader" made by Showa Engineering Kabushiki Kaisha) was charged with 5 10 kg. of TFE-hexafluoropropylene (hexafluoropropylene being hereinafter referred to as "HFP") copolymer (TFE/HFP = 88/12 by mole) having a particle size of 60 meshes pass and a prescribed amount of a thermal stabilizer shown in Table 1, and the agitating blades were rotated for 30 minutes at a 10 speed of 1,500 r.p.m. to give a fluorine-containing resin composition in the form of powder.

A rectangular frame having a size of 10 cm. X 5 cm. was placed on an aluminum plate, and the composition in the form of powder was placed in the frame in an amount 15 calculated on the basis of the specific gravity of the obtained film after sintering so that the film may have a thickness of 50 μ , 100 μ , 150 μ , 200 μ , 250 μ , 300 μ or 600 μ . After removing the frame gently, the composition on the aluminum plate was sintered in an electric oven at a 20 temperature of $345^{\circ} \pm 5^{\circ}\text{C}$. for 2 hours.

After the completion of the sintering, appearance of the obtained film was observed. The appearance was judged on the basis of the state of foaming of the film having a thickness of 100 μ obtained in Comparative 25 Example 1 in which no thermal stabilizer was used, according to the following criteria.

X: State of foaming being the same as the standard film having a thickness of 100 μ obtained in Comparative Example 1 in which an infinite number of foams having

diameter of not more than 1 mm. were present

XX: State of foaming being inferior to the standard film

△: State of foaming being improved to some extent as compared with the standard film

5 ○: Only several foams being present

○: No foam being observed

Although the films were prepared by a method different from usual powder coating method in order to adjust exactly the thickness of the films, the above.

10 sintering conditions are approximately the same as those applied to the practical powder coating, and it was also confirmed that the state of foaming well corresponded to that in the practical powder coating.

The results are shown in Table 1.

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Table 1

Com. Ex.	Thermal stabilizer	Kind	Amount (PHR)	State of films					
				50 μ	100 μ	150 μ	200 μ	250 μ	300 μ
Ex. 1	Phenyl- β -naphthylamine		1	○	×	XX	XX	XX	XX
Ex. 2	"		2	○	○	○	×	XX	XX
Ex. 3	Di- β -naphthyl-p-phenylenediamine		0.5	○	△	△	XX	XX	XX
Ex. 4	"		1	○	○	○	○	△	XX
Ex. 5	"		2	○	○	○	○	○	○
Ex. 6	Reaction product of diphenylamine and diisobutylene		0.5	○	○	△	×	○	○
Ex. 7	"		1	○	○	○	△	×	XX
Ex. 8	"		2	○	○	○	○	○	○
Ex. 9	4,4'-Bis(α -dimethylbenzyl)diphenylamine		0.5	○	△	×	XX	XX	XX
Ex. 10	"		1	○	○	○	△	△	XX
Ex. 11	"		2	○	○	○	○	○	○
Ex. 12	2-Mercaptobenzimidazole		1	○	○	○	△	○	○
Ex. 13	"		2	○	○	○	○	○	○

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	Thermal stabilizer	Kind	Amount (PHR)	State of films					
				50μ	100μ	150μ	200μ	250μ	300μ
Ex. 14	Zinc salt of 2-mercaptopbenzimidazole	"	1	○	○	○	○	○	○
Ex. 15	"	"	2	○	○	○	○	○	○
Ex. 16	2-Mercaptobenzothiazole	"	1	○	○	△	×	×	△
Ex. 17	"	"	2	○	○	○	○	○	XX
Ex. 18	Zinc salt of 2-mercaptopbenzothiazole	"	1	○	○	○	○	○	XX
Ex. 19	"	"	2	○	○	○	○	○	○
Ex. 20	Zinc ethylphenyldithiocarbamate	"	1	○	○	○	○	○	XX
Ex. 21	"	"	2	○	○	○	○	○	XX
Ex. 22	Zinc dibutylthiocarbamate	"	1	○	○	○	○	○	XX
Ex. 23	"	"	2	○	○	○	○	○	△
Ex. 24	Tetramethylthiuram disulfide	"	1	○	○	△	×	×	XX
Ex. 25	"	"	2	○	○	○	○	○	XX
Ex. 26	Dibutyl tin maleate	"	1	○	△	×	×	×	XX
Ex. 27	"	"	2	○	△	×	×	×	XX

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	Thermal stabilizer	Kind	Amount (PHR)	State of films					
				50 μ	100 μ	150 μ	200 μ	250 μ	300 μ
Ex. 28	Dibutyl tin mercaptide*		1	○	○	○	○	△	X
Ex. 29	"		2	○	○	○	○	○	XX
Ex. 30	Mixture of zinc dibutylthiocarbamate and di- β -naphthyl-p-phenylenediamine (1 : 1 by weight)		1	○	○	○	○	△	△
Ex. 31	"		2	○	○	○	○	○	XX
Ex. 32	Mixture of 2-mercaptopbenzothiazole and phenyl- β -naphthylamine (1 : 1 by weight)		1	○	○	○	○	△	△
Ex. 33	"		2	○	○	○	○	○	XX
Ex. 34	Mixture of dibutyl tin mercaptide and 2-mercaptopbenzoimidazole (1 : 2 by weight)		1	○	○	○	○	○	△
Ex. 35	"		2	○	○	○	○	○	○
Ex. 36	Mixture of dibutyl tin mercaptide and zinc salt of 2-mercaptopbenzothiazole (1 : 1 by weight)		1	○	○	○	○	○	△
Ex. 37	"		2	○	○	○	○	○	○

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	Kind	Amount (PHR)	State of films					
			50μ	100μ	150μ	200μ	250μ	300μ
Mixture of 4,4'-bis(α-dimethylbenzyl)-diphenylamine and zinc salt of 2-mercaptopbenzoazole								
Ex. 38	"	1	○	○	○	○	○	○
Ex. 39	"	2	○	○	○	○	○	○
Ex. 40	Tin powder	0.5	○	○	△	×	○	○
Ex. 41	"	1	○	○	○	○	○	△
Ex. 42	"	2	○	○	○	○	○	○
Ex. 43	Zinc powder	2	○	○	○	○	○	○
Ex. 44	Mixture of tin powder and zinc powder (1 : 1 by weight)	2	○	○	○	○	○	○

(Note) *Dibutyl tin mercaptide commercially available under the trademark "AP-52" made by Tokyo Fine Chemical Kabushiki Kaisha

Examples 45 to 48 and Comparative Examples 2 to 4

The procedures of the preceding Examples were repeated except that a melt-processable fluorine-containing resin (particle size: 60 meshes pass) and a thermal stabilizer 5 were employed as shown in Table 2 where the composition of VdF-TFE copolymer was VdF/TFE = 87/13 by mole and particle sizes of zinc powder and tin powder were 1 to 2 μ and not more than 74 μ respectively.

The results are shown in Table 2.

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Table 2

Thermal stabilizer	Fluorine-containing resin	Sintering condition			State of films		
		Kind	Amount (PHR)	°C.	hour	200μ	300μ
Ex. 45 Tin powder	-	VdF homopolymer	2	260	3	○	○
Ex. 46 Tin powder	-	VdF-TFE copolymer	2	260	3	○	○
Ex. 47 Zinc powder	-	VdF homopolymer	2	260	3	○	○
Ex. 48 Di-β-naphthyl-p-phenylenediamine	2	CTFE homopolymer	-	300	5	○	○
Com. Ex. 2	-	VdF homopolymer	-	260	3	○	△ X
Com. Ex. 3	-	VdF-TFE copolymer	-	260	3	○	△ X
Com. Ex. 4	-	CTFE homopolymer	-	300	5	○	△ X XX

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Example 49

The same 50 liter kneader as employed in the preceding Examples was charged with 10 kg. of TFE-HFP copolymer (TFE/HFP = 85/15 by mole) having a particle size of 60 meshes pass and a prescribed amount of tin powder stabilizer having a particle size of not more than 43 μ , and dry blending was carried out for 30 minutes at a speed of 1,500 r.p.m. to give a fluorine-containing resin composition in the form of powder.

10 The composition was placed in a fluidized bed. The powder was fluidized and a steel plate having a thickness of 10 mm. which was previously preheated to 380°C. was dipped in the fluidized powder layer to adhere the powder to the plate in such an amount as to give, after 15 sintering, a film having a thickness of 500 \pm 50 μ .

The thus obtained coating test specimen was placed in a hot air circulating oven, and was sintered under varied temperature and time conditions to determine critical sintering condition under which a film leaving no traces of foaming could be obtained.

20 The results are shown in Fig. 1, in which curves 1, 2, 3 and 4 show the cases using tin powder in amounts of 0.5, 1, 2 and 3 parts, respectively, per 100 parts of the resin.

25

Example 50

The procedures of Example 49 were repeated except that a mixture of tin powder having a particle size of not more than 74 μ and zinc powder having a particle size of 1 to 2 μ (2 : 1 by weight).

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The results of the determination of critical sintering condition are shown in Fig. 2, in which curves 5, 6 and 7 show the cases using the mixture as a thermal stabilizer in amounts of 0.5, 1 and 2 parts, respectively, per 100 parts of the resin.

Example 51

The procedures of Example 49 were repeated except that 0.5 part of carbon black per 100 parts of the resin was further employed as a pigment in addition to the resin and the thermal stabilizer.

The results of the determination of critical sintering condition are shown in Fig. 3, in which curves 8, 9 and 10 show the cases using the tin powder stabilizer in amounts of 0.5, 1 and 2 parts, respectively, per 100 parts of the resin.

It is observed from the comparison of Fig. 3 with Fig. 1 that the thermal stabilization effect cannot be impaired by the addition of additives such as pigments and reinforcing agents.

Examples 52 to 73 and Comparative Examples 5 to 9

A melt-processable fluorine-containing resin composition in the form of powder was prepared in the same manner as in Examples 1 to 44 except that a fluorine-containing resin having a particle size of 60 meshes pass and a thermal stabilizer were employed as shown in Table 2.

The composition was placed in a fluidized bed, and the powder was fluidized. A steel plate having a

thickness of 10 mm. which was previously preheated to 350°C. was then dipped to adhere the powder to the plate. The powder adhered to the plate was then sintered under a condition shown in Table 2 to give a test specimen having a 5 film of $300 \pm 50 \mu$ in thickness.

The thus obtained test specimen was placed in an autoclave containing high pressure saturated steam, and steam resistance test was carried out. The high pressure steam resistance of the film was judged according to the following 10 criteria.

- : No change
- △: Whitening (a large number of fine hair cracks being observable by a microscope of about 40 magnifications)
- ×: Occurrence of cracks observable by the naked eye

15 The results of the high pressure steam resistance are shown in Table 2 together with the results of Comparative Examples where no thermal stabilizer was employed. In Table 2, the employed zinc powder and tin powder are those having particle sizes of 1 to 2 μ and not more than 20 74 μ , respectively.

As is clear from the results, the compositions containing thermal stabilizers prepared according to the present invention have an improved durability to sintering, while the films containing no thermal stabilizer as shown 25 in Comparative Examples are thermally deteriorated in part under a severe sintering condition and is colored and it is considered that this causes lowering of the stress crack resistance in a high pressure steam.

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Table 3

Fluorine-containing resin				Thermal stabilizer		High pressure steam resistance			
Com.	Kind (molar ratio)	Sintering condition °C.	Kind hour			Amount PHR	120°C. 40 days	140°C. 7 days	160°C. 1 day
				17.0/6.5/76.5	290 0.5				
Ex. 5	E/P/TFE = 17.0/6.5/76.5	290	0.5	-	-	-	○	○	○
Com. Ex. 6	"	270	2	-	-	-	△	×	×
Ex. 52	E/P/TFE = 17.0/6.5/76.5	270,	2	Tetramethylthiuram disulfide	1	○	○	○	○
Ex. 53	"	"	"	"	2	○	○	○	△
Ex. 54	"	"	"	Di-β-naphthyl-p-phenylene- diamine	2	○	△	×	×
Ex. 55	"	"	"	"	3	○	△~○	×	×
Ex. 56	"	"	"	Zinc salt of 2-mercaptopbenzo- imidazole	1	○	○	○	×
Ex. 57	"	"	"	"	2	○	○	○	△~○
Ex. 58	"	"	"	Zinc dibutyldithiocarbamate	1	○	△~○	△	△
Ex. 59	"	"	"	"	2	○	○	○	○

25

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Fluorine-containing resin			Thermal stabilizer			High pressure steam resistance		
	Sintering condition	Kind (molar ratio)		Kind	Amount			
Com.	0C.	hour	Ex.	0C.	PHR	120° C. 40 days	140° C. 7 days	160° C. 1 day
Ex. 7	E/CTFE = 19.5/80.5	250	0.5	-	-	-	△~○	△~○ △
Com.	"	260	2	-	-	-	X	X~△ X
Ex. 8	-	-	-	-	-	-	-	-
Ex. 60	E/CTFE = 19.5/80.5	260	2	Zinc salt of 2-mercaptopbenzoizazole	2	○	○	△~○
Ex. 61	"	"	"	Zinc salt of 2-mercaptopbenzoimidazole	2	○	○	○
Ex. 62	"	"	"	Reaction product of diphenylamine and diisobutylene	2	○	○	△
Ex. 63	"	"	"	"	3	○	○	○
Ex. 64	"	"	"	Zinc ethylphenyldithiocarbamate	2	○	○	△
Ex. 65	"	"	"	"	3	○	○	○
Ex. 66	"	"	"	Tetramethylthiuram disulfide	1	○	△	X
Ex. 67	"	"	"	"	2	○	△~○	X

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Fluorine-containing resin				Thermal stabilizer	High pressure steam resistance		
Kind (molar ratio)	Sintering condition °C.	Kind	Amount PHR	27			
				120°C. 40 days	140°C. 7 days	160°C. 1 day	
Ex. 68 E/P/TFE = 17.0/6.5/76.5	270	2	Tin powder	0.5	○	○	△~○
Ex. 69 "	"	"	"	1	○	○	△
Ex. 70 E/CTFE = 19.5/80.5	260	2	Tin powder	2	○	○	X
Ex. 71 "	260	0.5	Mixture of tin and zinc powders (1 : 1 by weight)	2	○	○	○
Com. Ex. 9 E/TFE = 19.8/80.2	320	2	-	-	△	△~X	X
Ex. 72 E/TFE = 19.8/80.2	320	2	Tin powder	1	○	○	○
Ex. 73 "	"	"	Zinc powder	1	○	△~○	○

(Note) E: Ethylene

P: Propylene

Examples 74 to 91 and Comparative Example 10

In a ball mill, 200 parts of xylene, 350 parts of cyclohexane, 300 parts of finely divided TFE-HFP copolymer (TFE/HFP = 86/14 by mole) having a particle size of 150
5 meshes pass and a prescribed amount of a thermal stabilizer as shown in Table 4 were blended for 24 hours to give a dispersion of resin and stabilizer in organic solvent.

The obtained dispersion was sprayed to aluminum plates to give coated plates having coatings of various
10 thicknesses. After drying the coatings in an infrared dryer maintained at 100°C., the coated plates were placed in a hot air circulating type electric oven and then sintered at 350°C. for 1.5 hours. Limit thickness to foaming being capable of providing a good sintered film leaving no traces
15 of foaming was then judged.

The results are shown in Table 4, in which the employed zinc powder and tin powder are those having particle sizes of 1 to 2 μ and not more than 43 μ , respectively.

As is clear from the results shown in Table 4,
20 fluorine-containing resin compositions in the form of dispersion of the present invention can be coated more thickly as compared with the dispersion not containing thermal stabilizer obtained in Comparative Example 10.

Table 4

	Thermal stabilizer	Amount Kind	Limit thick- ness to foam- ing in sin- (PHR)	tered film (μ)
Com.				
Ex. 10				70 to 80
Ex. 74	Di- β -naphthyl-p-phenylenediamine	1	120 to 130	
Ex. 75	"	2	200 to 220	
Ex. 76	Reaction product of diphenylamine and diisobutylene	1	150 to 170	
Ex. 77	"	2	250 to 260	
Ex. 78	Zinc salt of 2-mercaptopbenzo- imidazole	0.5	150 to 160	
Ex. 79	"	1	240 to 250	
Ex. 80	Tin salt of 2-mercaptopbenzo- thiazole	0.5	180 to 200	
Ex. 81	"	1	280 to 300	
Ex. 82	Zinc dibutyldithiocarbamate	1	190 to 210	
Ex. 83	"	2	>300	
Ex. 84	Tetramethylthiuram disulfide	1	120 to 140	
Ex. 85	"	2	180 to 200	
Ex. 86	Dimethyl tin mercaptide*	0.5	160 to 170	
Ex. 87	"	1	220 to 230	
Ex. 88	Zinc powder	0.5	190 to 200	
Ex. 89	"	1	>300	
Ex. 90	Tin powder	0.5	210 to 222	
Ex. 91	"	1	>300	

(Note) *Dibutyl tin mercaptide commercially available under
the tradename "AP-52" made by Tokyo Fine Chemical
Kabushiki Kaisha

WHAT WE CLAIM IS:

1 1. A melt-processable fluorine-containing resin
2 composition having an improved thermal stability which
3 comprises a melt-processable fluorine-containing resin
4 selected from the group consisting of a tetrafluoroethylene
5 copolymer, chlorotrifluoroethylene homopolymer, a
6 chlorotrifluoroethylene copolymer, vinylidene fluoride
7 homopolymer and a vinylidene fluoride copolymer, and at
8 least one thermal stabilizer selected from the group
9 consisting of an amine antioxidant, an organosulfurous
10 compound, an organo tin antioxidant, a tin powder and a
11 zinc powder.

1 2. The composition of Claim 1, wherein said thermal
] stabilizer is present in an amount of 0.05 to 10 parts by
3 weight per 100 parts by weight of the resin.

1 3. The composition of Claim 1, wherein said
2 organosulfurous compound is at least one member selected from
3 the group consisting of benzimidazole type mercaptan
4 compounds and their metal salts, benzothiazole type
5 mercaptan compounds and their metal salts, dithiocarbamic
6 acids and their metal salts and thiuram compounds.

1 4. The composition of Claim 1, wherein said
2 organo tin antioxidant is a compound having the following
3 general formula:

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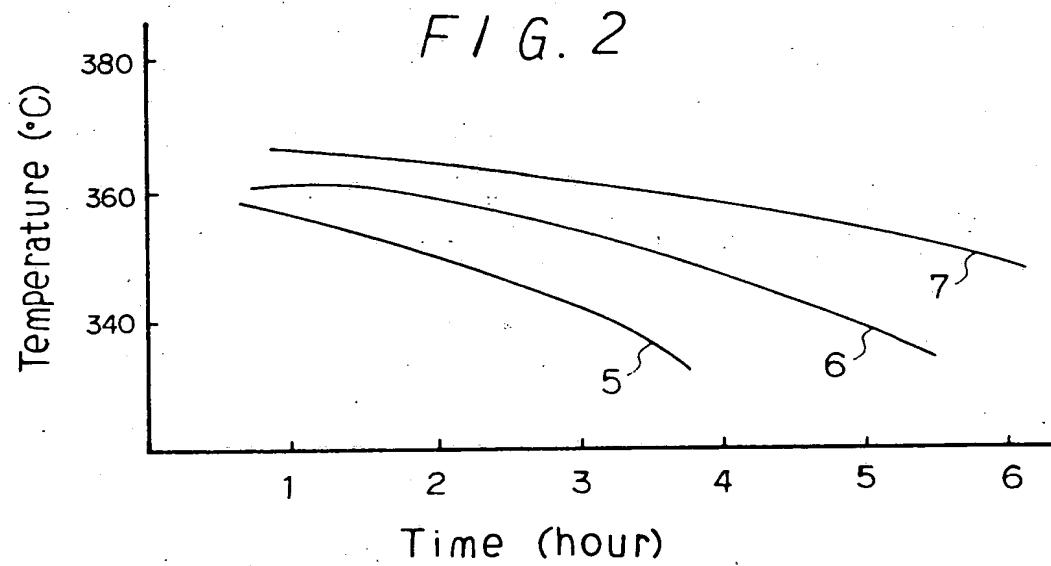
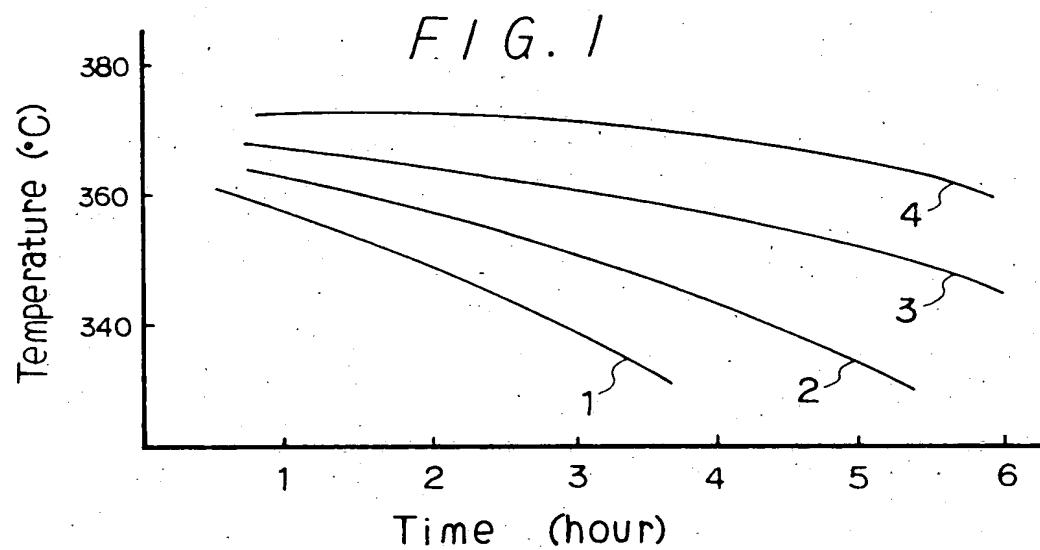
5 wherein R¹ and R² are the same or different and each is an
6 alkyl or aryl group having 2 to 16 carbon atoms, and Y is
7 a residue of an acid, an alcohol or an mercaptan.

1 5. The composition of Claim 1, wherein said melt-
2 processable fluorine-containing resin is a tetrafluoro-
3 ethylene copolymer or a chlorotrifluoroethylene copolymer.

1 6. The composition of Claim 1, wherein said melt-
2 processable fluorine-containing resin is a tetrafluoro-
3 ethylene-hexafluoropropylene copolymer.

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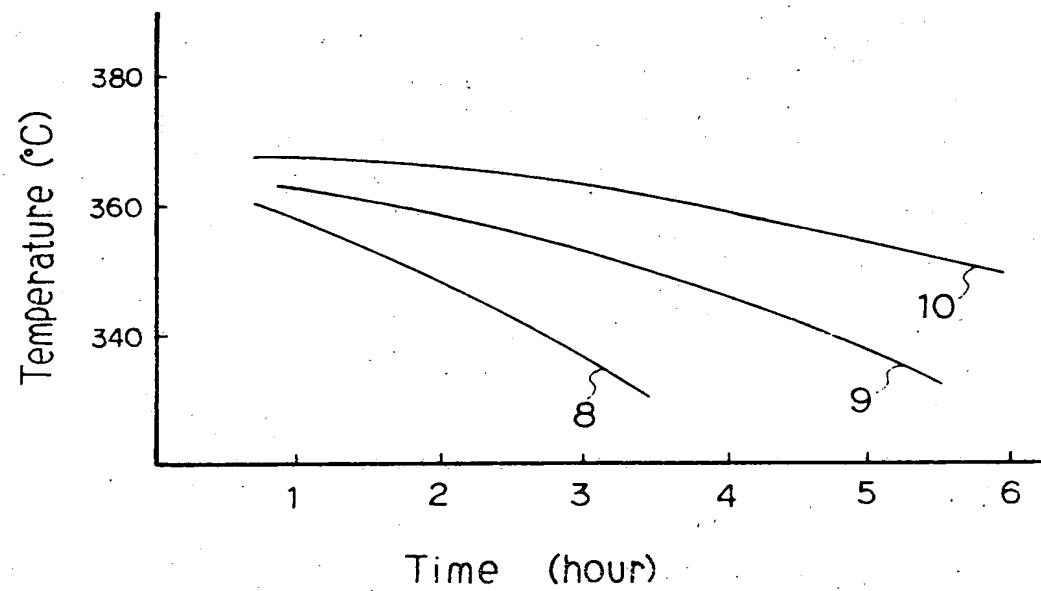
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FIG. 3



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European Patent
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EUROPEAN SEARCH REPORT

Application number

79101784.1

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
X	US - A - 3 557 050 (SHUN KOIZUMI et al) + Totality + --	1 - 3, 5,6.	C 08 L 27/12 C 08 K 5/00
X	US - A - 3 557 051 (YUTAKA KOMETANI) + Totality + --	1 - 3, 5,6	
X	US - A - 2 874 143 (WILLIAM S. BARNHART) + Totality + --	1, 4	
X	KUNSTSTOFF-HANDBUCH VOL. XI (C. Hanser Verlag München 1971) + Page 409, line 21 - 23 + -----	1	C 08 L 27/12 C 08 L 27/14 C 08 L 27/16 C 08 L 27/18 C 08 K 3/08 C 08 K 5/16 C 08 K 5/37 C 08 K 5/38 C 08 K 5/45 C 08 K 5/57
			CATEGORY OF CITED DOCUMENTS
			X: particularly relevant A: technological background O: non-written disclosure P: Intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons
			&: member of the same patent family, corresponding document
<input checked="" type="checkbox"/>	The present search report has been drawn up for all claims		
Place of search	Date of completion of the search	Examiner	
VIENNA	25-07-1979	DICHER	